

Chemicals Manufacturing, Except Drugs

(SIC 28, except 283)

SIGNIFICANT POINTS

- Employment is projected to decline.
- Most jobs in research and development require substantial technical education after high school, but opportunities exist for persons with degrees ranging from a 2-year associate degree up to a doctorate.
- Production workers earn more than in most industries.

Nature of the Industry

Passing a large chemical plant, one might see a large maze of tanks, pressure vessels, and twisting pipes, but most of us do not realize that goods produced by chemical plants account for over six percent of the total value of manufacturing in the United States. Although some chemical manufacturers produce and sell consumer products such as soap, bleach, and cosmetics, most chemical products are used as intermediate products for other goods.

Chemical manufacturing is divided into eight segments, seven of which are covered here. These industry segments include plastics materials, cleaning preparations, inorganic chemicals, organic chemicals, miscellaneous chemicals, agricultural chemicals, and drug manufacturing. The eighth segment, drug manufacturing, is covered in a separate *Career Guide* statement.

The largest employer of the segments included here is the plastics materials and synthetics industry, which produces a wide variety of finished products as well as raw materials. Some of these include polypropylene, polyvinyl chloride (PVC), and polystyrene, which can be made into products such as loudspeakers, PVC pipes, and beverage bottles; the automotive manufacturers are particularly large users of these products. Another segment of the industry includes firms making soaps, detergents, and cleaning preparations. Cosmetics and toiletries are also included in this segment. Households and businesses use these products in many ways, cleaning everything from babies to bridges. This is the only segment of the chemical industry in which much of the production is geared directly toward consumers.

The industrial organic chemicals segment produces chemicals that contain carbon and are made primarily from petroleum and natural gas, and are often referred to as petrochemicals. Although organic chemicals are used to make dyes, plastics, and pharmaceutical products, most of these chemicals are used in the production of other chemicals.

Industrial inorganic chemicals are usually made from salts, other minerals, and metal compounds. This segment also includes industrial gases such as oxygen, nitrogen, and helium. Inorganic chemicals are often used by businesses as reaction aids. Other chemical companies are the largest single customer of this segment.

The fifth largest employer in the chemical industry is the miscellaneous chemical product sector. This segment manufactures adhesives, explosives and fireworks, inks, and many other products used by consumers or in the manufacture of other products.

The paints and allied products segment includes paints, varnishes, lacquers, putties, paint removers, sealers, and stains. The construction and furniture industries are large customers of this segment. Other customers range from individuals refurbishing their homes to businesses that need anti-corrosive paints that can withstand high temperatures.

Finally, the segment employing the fewest number of workers in the chemical industry is agricultural chemicals. This segment supplies farmers and home gardeners with fertilizers, herbicides, pesticides, and other agricultural chemicals.

Chemicals are generally classified into two groups—commodity chemicals and specialty chemicals. Commodity chemical manufacturers produce large quantities of basic and relatively inexpensive compounds using large plants often built specifically to make one chemical. Specialty chemical manufacturers commonly produce smaller quantities of more expensive chemicals that are used less frequently. Specialty manufacturers often supply larger chemical companies on a contract basis. Many traditionally commodity chemical manufacturers are becoming specialty chemical manufacturers to better compete.

Table 1. Distribution of employment in chemicals and allied products, 1998

Industry	Employment	Percent
Total, all industries	763,800	100.0
Plastics materials and synthetics	157,000	20.6
Soaps, cleaners, and toilet goods	155,500	20.4
Industrial organic chemicals	137,700	18.0
Industrial inorganic chemicals	115,400	15.1
Miscellaneous chemicals	93,900	12.3
Paints and allied products	52,300	6.8
Agricultural chemicals	52,000	6.8

The diversity of products produced by the chemical industry also is reflected in the establishments that comprise it. For example, firms producing plastics materials operated relatively large plants in 1997. This segment had 8 percent of the reporting establishments, yet employed almost 21 percent of those working in the chemical manufacturing industry. On the other hand, manufacturers of paints and allied products had a greater number of establishments, each employing a much smaller number of workers. This segment comprised over 14 percent of the establishments in the chemical industry, yet employed only 8

percent of all workers. The average workplace in the chemical industry ranged from 138 workers in the plastics materials segment to 35 workers in the soaps and cosmetics segment.

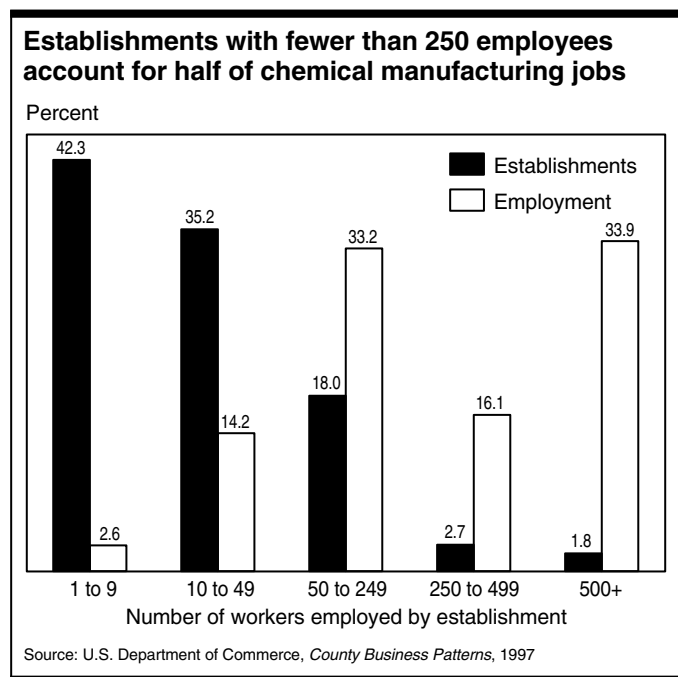
The chemical industry segments vary in the degree to which their workers are involved in production activities, administration and management, or research and development. Industries that make products such as cosmetics or paint that are ready for sale to the final consumer employ more administrative and marketing personnel. Industries that market their products mostly to industrial customers generally employ a greater proportion of precision production workers and a lower proportion of unskilled labor.

Chemical firms are concentrated in areas abundant with other manufacturing businesses, such as in the Great Lakes region near the automotive industry, or on the West Coast near the electronics industry. Chemical plants are also located near the petroleum and natural gas production centers of the South. Because chemical production processes often use water and chemicals are exported all over the world, primarily by ship, major industrial ports are another common location of chemical plants. California, Illinois, New Jersey, New York, Ohio, Pennsylvania, South Carolina, Tennessee, and Texas had about 50 percent of the establishments in the industry.

Working Conditions

Manufacturing chemicals usually is a continuous process; this means that once a process has begun, it cannot be stopped when it is time for workers to go home. Split, weekend, and night shifts are common, and workers on such schedules are usually compensated with higher rates of pay. As a result, the average workweek in the chemical industry was over 43 hours in 1998, over 2 hours longer than the average for nondurable manufacturing industries, and over 8 hours longer than the average for all private industries. The industry employs relatively few part-time workers.

The plants usually are clean, although the continually running machines sometimes are loud. Hardhats and safety goggles are worn throughout the plant.



Hazards in the chemical industry can be substantial, but they are generally avoided through strict safety procedures. Workers require protective gear and extensive knowledge of the dangers associated with the chemicals being handled. Body suits with breathing devices designed to filter out any harmful fumes are mandatory for work in dangerous environments.

In spite of the hazards of working with chemicals, extensive worker training on handling hazardous chemicals and chemical company safety measures have resulted in injury and illness rates for some segments of the chemical industry that are much lower than the average for the manufacturing sector. The chemical industry reported just 4.8 cases per 100 workers of work-related injury or illness, compared to an average of 10.3 cases for all manufacturing industries in 1997.

Employment

The chemical and allied products industry employed about 763,800 wage and salary workers in 1998, about 4.1 percent of the total number employed in manufacturing and over 10 percent of the total number employed in nondurable goods manufacturing. Most segments of the industry had substantial numbers of jobs, as shown in table 1. Employment in the chemical industry has declined recently as chemical companies have increased productivity and reduced costs by eliminating all but the most essential personnel.

Occupations in the Industry

Over half of those employed in the industry work in precision production, craft, and repair and operator, fabricator, and laborer occupations. Another one-quarter work in executive, managerial, and administrative occupations. The third largest group, with about one-fifth of chemical industry employment, are in professional specialty, technical, and marketing occupations. The remaining workers are in service and related occupations (table 2).

Production. Workers in production occupations operate and fix plant machinery, transport raw materials, and monitor the production process. Improvements in technology gradually are increasing the level of plant automation, reducing the number of jobs in production occupations. Although high school graduates qualify for most entry level production jobs, advancement into better paying jobs, requiring higher skills or more responsibility, is possible with on-the-job training and work experience or through additional vocational training at a 2-year technical college.

Chemical plant and system operators monitor the entire production process. From chemical ingredient ratios to chemical reaction rates, the operator is responsible for the efficient operation of the chemical plant. Chemical plant operators advance to these positions generally from among the most experienced production workers, usually after having acquired extensive experience and technical training in chemical production processes. Experienced operators sometimes advance to senior supervisory positions.

Chemical equipment controllers monitor the flow and mix ratios of chemicals moving through production equipment. Experienced workers advance to controller positions after demonstrating their ability to handle more responsibility in lower skilled jobs. Sometimes new engineers in training are temporarily assigned to controller positions to learn the production process first-hand. Undergraduate engineering students in co-

operative education programs also may work in these positions temporarily as a means of gaining hands-on experience in their field before graduating from college.

Table 2. Employment of wage and salary workers in chemical and allied products by occupation, 1998 and projected change, 1998-2008

(Employment in thousands)

Occupation	1998		1998-2008 Percent change
	Number	Percent	
All occupations	764	100.0	-3.9
Operators, fabricators, and laborers ...	274	35.9	1.6
Chemical equipment controllers	50	6.5	16.2
Helpers, laborers, and material movers, hand	43	5.6	-5.0
Packaging and filling machine operators	31	4.0	11.4
Crushing, grinding, mixing and blending machine operators	28	3.7	-3.1
Hand workers, including assemblers and fabricators	25	3.2	1.7
Truck drivers	13	1.8	-7.0
Extruding and forming machine operators, synthetic or glass fibers	13	1.8	7.7
Industrial truck and tractor operators	8	1.1	-3.2
Textile draw-out and winding machine operators	9	1.2	-22.5
Precision production, craft, and repair	170	22.2	-4.6
Blue-collar worker supervisors	42	5.4	-5.9
Chemical plant and system operators	36	4.7	10.6
Maintenance repairers, general utility	19	2.5	-15.0
Industrial machinery mechanics	21	2.8	-4.3
Inspectors, testers, and graders	11	1.5	-18.2
Administrative support, including clerical	86	11.2	-13.8
Secretaries	16	2.1	-24.4
Shipping, receiving, and traffic clerks	11	1.4	-11.2
General office clerks	10	1.4	-3.8
Bookkeeping, accounting, and auditing clerks	8	1.1	-21.8
Executive, managerial, and administrative	88	11.5	-6.1
Management support occupations	26	3.5	-7.4
General managers and top executives	16	2.1	-6.9
Industrial production managers	11	1.5	-6.9
Engineering, science, and computer and information systems managers	6	0.8	11.8
Marketing, advertising, and public relations managers	8	1.0	-2.1
Professional specialty	65	8.6	-2.2
Chemists	17	2.2	-10.6
Chemical engineers	17	2.2	7.1
Computer systems analysts, engineers, and scientists	6	0.8	31.0
Technicians and related	41	5.4	-13.6
Science and mathematics technicians ..	30	4.0	-14.3
Engineering technicians	8	1.1	-8.3
Marketing and sales	31	4.1	-3.2
Service	7	0.9	-12.3

Mechanics, installers, and repairers repair equipment, install machines, or practice preventive maintenance in the plant. Workers advance to these jobs either through apprenticeships, formal vocational training, or by completing in-house training courses.

Inspectors, testers, and graders assure that the production process runs efficiently and that products are of acceptable quality. They refer problems to plant operators or management.

Packaging and filling operators wrap products and fill boxes to prepare the final product for shipment or sale to the wholesaler or consumer. Over half of these jobs are in the soap and cosmetics industry, due to the amount of packaging needed for this industry's consumer products.

Transportation and material moving workers move materials around the plant using industrial trucks or deliver finished products to customers by truck. For these jobs, employers seek experienced workers with knowledge of chemical hazards, safety procedures, and regulations governing the transport of hazardous chemicals. Operation of industrial trucks and tractors can be learned with on-the-job training, but previous experience driving a truck and a commercial driver's license generally are required to operate a tractor trailer carrying chemicals.

Helper, laborer, and material mover jobs usually are open to workers without experience. These workers move raw materials and finished products through the chemical plant and assist motor vehicle operators in loading and unloading raw materials and chemicals. They learn safe ways to handle chemicals on the job and develop skills that enable them to advance to other occupations.

Research, development, and technical. Most workers in research and development have college degrees, and many have advanced degrees. Engineers, scientists, and technicians comprise a growing portion of industry employment.

Chemists conduct chemical research, analyze compounds, and experiment with liquids and gases. They try to develop new chemicals for specific applications and new applications for existing chemicals. The most senior chemists sometimes advance to management positions. Although chemical companies hire chemists with bachelor's degrees, a master's or doctoral degree is becoming more important for chemist jobs.

Chemical engineers design equipment and develop processes for manufacturing chemicals on a large scale. Chemical research engineers design and conduct experiments to learn how processes behave and conduct research for potential new chemical products and processes. A bachelor's degree is essential for these jobs, and a master's degree may be preferred or required for some jobs.

Engineering and science technicians assist chemists and engineers in research activities and may conduct some research independently. Those with bachelor's degrees in chemistry or graduates of 2-year technical institutes usually fill these positions. Some graduates of engineering programs start as technicians until an opportunity to advance into an engineering position arises.

Administration and management. Most managers need a 4-year college degree in addition to experience in the industry. As in other highly technical industries, top managerial

positions often are held by those with substantial technical experience. Employment in administrative support and managerial occupations is expected to decline as companies merge and consolidate operations.

Engineering and science managers conduct cost estimations, perform plant design feasibility studies, and coordinate daily operations. These jobs require a college degree in a technical discipline such as chemistry or chemical engineering and experience in the industry. Some employees advance from research and development positions to management positions.

Marketing and sales workers promote sales of chemical products by informing customers of company products and services. A bachelor's degree in marketing, chemistry, or chemical engineering usually is required for these jobs.

Administrative support workers perform office functions such as secretarial duties, bookkeeping, material records processing, and other clerical duties. Training beyond high school and familiarity with computers is preferred for these occupations.

Training and Advancement

The chemical industry has a wide variety of companies and products, which creates career opportunities for persons with varying levels of experience and education. Training and advancement differ for the three major categories of occupations in the chemical industry.

Production workers may start as laborers or in other unskilled jobs and, with experience and training, advance into better paying positions that require greater skills or have greater responsibility. Substantial advancement is possible even within a single occupation. For example, chemical plant operators may move up through several levels of responsibility until they reach the highest paying operator job. Advancement in production occupations usually requires mastery of advanced skills. Such skills usually are a combination of on-the-job-training and formal training provided by the employer. Some workers advance into supervisory positions.

Most jobs in research and development require substantial technical education after high school, but opportunities exist for persons with degrees ranging from a 2-year associate degree up to a doctorate. Development of new products and the award of patents bring increases in pay and prestige, but after a point advancement requires moving from research and development into management. Researchers usually are familiar with company objectives and production methods which, combined with college education, equips them with many of the tools necessary for management positions.

Managerial jobs usually require a 4-year college degree, though some may require only a 2-year technical degree. Managers can usually advance into higher level jobs without additional formal training outside the workplace, although competition is keen. In general, advancement into the highest management ranks depends on experience and proven ability to handle responsibility in several functional areas. Among larger worldwide firms, international experience is important for career advancement. Also, recent industry restructuring has left fewer layers of management, increasing competition for promotions.

Earnings

Wages of workers in the chemical industry vary according to occupation, the specific industry segment, and size of the

production plant. Earnings by major occupation group are shown in table 3 and earnings for the largest occupations in selected industries are shown in table 4.

Table 3. Median weekly earnings of full-time workers in chemical manufacturing, except drugs by occupation group, 1998

Occupation group	Median earnings
Professional specialty	\$1,044
Executive, administrative, and managerial	959
Technicians	739
Precision production, craft, and repair	673
Administrative support	535
Machine operators	501
Transportation and material moving	454
Handlers, equipment cleaners, and laborers	415

Earnings also vary by industry within the chemical industry. Median weekly earnings for production workers were highest in industrial organic chemicals, \$917, and lowest in soaps and cosmetics, \$577.

Table 4. Median hourly earnings of the largest occupations in selected chemicals manufacturing industries, 1997

Occupation	Industrial inorganic chemicals	Plastics materials and synthetics	Soaps, cleaners and toilet goods	Industrial organic chemicals	All industries
First-line supervisors and managers/supervisors-production and operating workers	—	\$20.06	—	\$23.50	\$16.62
Chemical plant and system operators	\$18.21	18.81	—	19.09	18.27
Chemical equipment controllers and operators	16.90	17.75	—	17.29	15.25
Chemical technicians and technologists, except health	—	—	—	16.97	14.89
Packaging and filling machine operators and tenders	—	—	\$10.72	—	9.38
Assemblers and fabricators, except machine, electrical, electronic, and precision ...	—	—	9.10	—	9.25
Hand packers and packagers	—	—	8.01	—	6.90

Earnings in the chemical industry are higher than average. The weekly earnings for all production workers in chemical manufacturing averaged \$740 in 1998, compared to \$563 in all manufacturing industries and \$442 throughout private industry. This was due, in part, to more overtime and weekend work, which command higher hourly rates.

The principal unions representing chemical workers are the Oil, Chemical, and Atomic Workers Union and the International Chemical Workers Union. Fifteen percent of chemical manufacturing workers are union members or are covered by union contracts, compared to 15.4 percent of all workers in private industry.

Outlook

Although the chemical industry's output is expected to grow, employment in the chemical and allied products industry,

excluding drugs, is projected to decline by 4 percent over the 1998-2008 period, compared to 15 percent growth expected for the entire economy. The expected decline in chemical manufacturing can be attributed to trends affecting the U.S. and global economies. More efficient production processes and increased plant automation, company mergers and consolidation, increased foreign competition, outsourcing of production, growth of environmental health and safety concerns and legislation, precision farming techniques, and an emphasis on specialty chemicals will influence chemical industry employment.

Improvements in production technology have reduced the need for workers in precision production, craft, and repair and operator, fabricator, and laborer occupations, which comprise over half of the jobs in the chemical industry. The growing application of computerized controls in standard production, and the growing manufacture of specialty chemicals requiring precise, computer-controlled production methods, will reduce the need for workers to monitor or directly operate equipment.

Foreign competition has been intensifying in most industries, and the chemical industry is no exception. Although the U.S. chemical industry has enjoyed a favorable trade balance for quite some time—a trend expected to continue—growing global trade and rapidly expanding foreign production capabilities should increase competition. Pressure to reduce costs and streamline production will result in the continuing mergers and consolidation of companies both within the United States and abroad. Mergers and consolidations are allowing chemical companies to increase profits by eliminating duplicate departments and shifting operations where costs are lowest. U.S. companies are expected to continue investing heavily in overseas production plants, taking advantage of expanding markets in some developing countries, East Asia and Latin America. Domestic production activities that are less automated will be affected by this shift of production abroad. Lower skilled production occupations should decline as a result.

To satisfy growing public environmental concerns, and comply with the many Government regulations, the chemical industry invests billions of dollars yearly in technology to reduce pollution and clean up existing waste sites. Growing concerns about chemicals and the environment will spur producers to create chemicals with fewer, less dangerous, or useable by-products that can be recycled or disposed of cleanly. This will require greater investment in research and development. As a result, occupations related to environmental compliance, improving product visibility, and promoting consumer confidence should grow slowly.

Precision farming techniques have reduced the demand for agricultural chemicals in this country as farmers use computer technology to determine what chemicals need to be applied in different areas of the farm, rather than simply fertilizing the whole farm. However, this reduced demand will be partially offset by the increase in global demand for agricultural chemicals as other countries become more sophisticated in their farming techniques.

Another trend in the chemical industry is the rising demand for specialty chemicals. Chemical companies are

finding that in order to remain competitive, they must differentiate their products and produce specialty chemicals, such as advanced polymers and plastics designed for specific uses—for example, a durable body panel on an automobile. Because advanced processes often produce specialty chemicals, this trend should increase employment opportunities for highly trained research and development and production-oriented chemists, chemical engineers, technicians, and production personnel. In these small to medium-size firms, responsiveness to customers' chemical needs is imperative, so opportunities for marketing staff such as sales engineers should also be available.

The factors affecting employment in the chemical manufacturing industry will impact different segments of the industry in varying degrees. The two segments projected to add jobs are miscellaneous chemical products, with an increase of about 4,100 jobs, and soap, cleaners, and toilet goods, with an increase of around 9,500 jobs. The two largest losers of jobs are plastics materials and synthetics, with about 16,000 fewer jobs projected, and industrial inorganic chemicals, with a projected loss of about 14,000 jobs.

In terms of specific occupations, employment opportunities in the chemical industry can be divided into production and nonproduction occupations. Jobs in production are expected to decline; the outlook is somewhat brighter for certain professional specialty jobs, such as chemical engineers and computer engineers and scientists. Employment in production occupations should continue to decline as the increasing automation of the chemical industry improves efficiency. The market shift to specialty chemicals, together with increasing competition, will give rise to more jobs in marketing and sales occupations, as companies differentiate their products and compete more heavily in the world marketplace. However, this rise in employment will likely be offset by the elimination of personnel as a result of company restructuring and mergers. In general, persons with technical and advanced degrees will have the best opportunities in the chemical industry.

Sources of Additional Information

Additional information on the chemical and allied products industry is available from:

- American Chemical Society, 1155 16th St. NW., Washington, DC 20036. Internet: <http://www.acs.org>
- American Institute of Chemical Engineers, 3 Park Ave., New York, NY 10016-5901. Internet: <http://www.aiche.org>

Detailed information on many occupations in the chemical industry, including the following, may be found in the 2000-01 edition of the *Occupational Outlook Handbook*.

- Blue-collar worker supervisors
- Chemical engineers
- Chemists
- Computer programmers
- Computer systems analysts, engineers, and scientists
- Engineering technicians
- Industrial production managers
- Material moving equipment operators